DIFFERENCE BETWEEN COMPACTING OF SOFTWOOD AND HARDWOOD

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ABSTRACT

The aim of this contribution is to present the results of experimental research into the compacting process which was carried out in our department. We would like to present the differences between compacting of softwood and hardwood. The type of material which we will compact is very important and is the determining factor which influences the final briquette quality. Briquette quality is evaluated mainly by the briquette density. Briquette density is very important from the point of view of manipulation, burning speed, briquette stability, etc. In this contribution we want to present the importance of the change of the input pressed material on the compacting process from the point of view of the density of the final briquette.
Keywords: type of compacted material, compacting pressure, pressing temperature, briquette density, mathematical model of compacting

INTRODUCTION

Nowadays, the use of solid biofuels is interesting and popular. Solid biofuels are produced by compacting machines most usually from wood wastes, (chips, piece of wood waste, sawdust, topwood, coarse wood after mining, waste from forest management, tree stumps, roots, etc…). If we use solid biofuels with accumulated energy values the combustion process is as effective as burning a piece wood waste. At the present time we know many producers of compacting machines with a wide range of machines. But not every machine can produce biofuels (briquettes or pellets) to the required quality Standards. This fact demonstrates the many problems which have to be solved. The properties of the compacted material as well as technological demands are both very important to the briquette production process. The input material needs to be reduced to the optimal particle size, to dry to optimal moisture content level and we have to provide optimal technological parameters throughout the process of compacting. These optimal values are optimal according to the briquette's quality which is set by EU Standards. Every type of material requires an independent approach. Each small change in the properties of the input materials (as you can see in article) can influence the final quality of the briquette. Different material properties cause different conditions during the compacting process. In this contribution factors influencing briquettes quality were specified and assigned.

PROPERTIES OF PRESSED MATERIAL

We are sure that everybody can imagine different material characteristic for example between wood and textile. In the following Figure 1 you can see the differences in density between briquettes of various different materials. Can you imagine the differences between softwoods and hardwoods from the compacting process quality point of view? And what about the differences between pine and spruce wood from the compacting process quality point of view? Therefore we decided to describe the properties of typical wood materials. This will have an influence on the

compacting process quality. These properties represent the differences between individual materials. With various types of materials and various input conditions we can obtain various properties of the briquettes, such as caloric value, moisture content, and ash content.

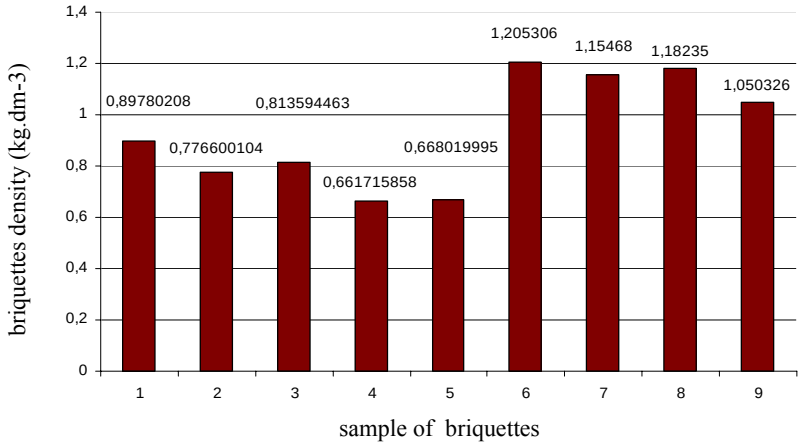

Fig. 1 Comparison of some briquettes density from various types of materials: 1-mixed municipal waste (wood 38%, paper 45%, PET bottles 11%, textile 6%); 2-RDF with addition of 20% of disintegrated carton waste; 3-RDF with addition of 4% of cement; 4-RDF with addition of 20% of wood sawdust; 5-Clear RDF; 6-Softwood; 7-Cacao cracks; 8-Hardwood; 9-Corn straw [1], [2].

We know the following basic properties of the material: the chemical composition of the material; the material density; the material weight; the moisture content of the material; the material contexture and structure; the fraction porosity; the fraction size; the material's caloric value and others. After analyses carried out in our department we know that final briquette quality is significantly affected by the chemical composition of the material, its density, its moisture content, the material contexture and structure which is shown mainly by the size of the chips.
Some words about these material properties.
[3] The chemical composition of biomass or wood differs between individual plants. On average plants contain approximately 25 % of lignin and 75 % of hydrocarbons or sugars. Hydrocarbon units consist of many molecules of sugars joined in long chains of polymers. Two important units of hydrocarbons are cellulose and hemi cellulose. Nature uses the long polymers of cellulose for fiber building which gives plants the strength they need. Lignin acts as glue which holds together cellulose fibers. Differences occur not only in the chemical composition between groups of softwoods and hardwoods (see Figure 2), but also between individual species of wood (see Tab 1).
[3] Every type of material has its own specific density, different from each others. Density significantly influences the mechanical and physical properties of the wood. The higher the specific density of the input material, the better the compacting of the final briquette. We can say that wood density is important in the mechanical and chemical treatment and its importance increases as the amount of wood increases. For example heavier wood is firmer, stronger and more wear resistance and more resistant to working than soft wood.
[1]; [3] Wood density and also wood weight is influenced mainly by moisture, by the width of the year rings and by the ratio of summer wood, the position in the stem and the age of the tree. Wood density and weight increase with moisture, whilst wood weight and volume are unchanged. Wood weight increases with the increase of moisture till it is fully saturated. Wood volume increases to the point of fiber saturation. By controlling the moisture increases the bound wood volume is unchanged. When the pressed material moisture is very low, and also when it is very high, that is

falling outside of the optimal range of 8 – 15%, the material particles aren't consistent and the briquettes fall apart. At lower moisture values the material isn't sintered, which is needed to produce consistency of the material particles in the briquette (see Figure 3). Research and experiment proved that moisture also has an impact on lignin plastification. The temperature of lignin softening depends also on the type of wood from which it is isolated and also on the isolation method. The temperature at which lignin switches from a solid to a plastic state is in direct proportion to its molecular weight, and in indirect proportion to its moisture content.

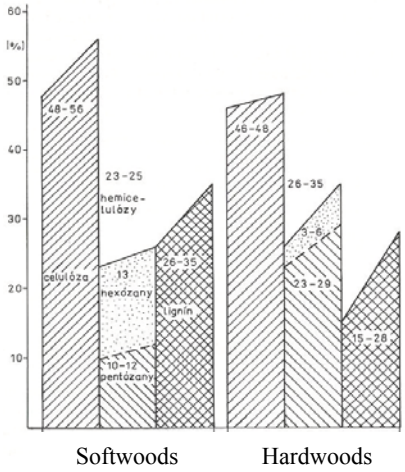

Fig. 2 Main organic units in softwoods and hardwoods [3].

Tab. 1: Chemical composition of some domestic woods [3]

	Spruce	Pine	Beech
Component	[%]	[%]	[%]
Cellulose	45,6	43,2	39,2
Hemi cellulose	27,6	28	35,3
Lignin	26,9	26,6	20,9

Fig. 3 Examples of ashlars shaped wood briquettes pressed from materials with different moisture content (left approx. 18 %, right approx. 10%).

From the pressing point of view it is very important to know the material composition, its structure and the particle size of the material. Particle structure and size significantly influences the binding mechanisms and the pressure required to achieve successful binding. They influence the fluency of the compacting process and the final quality of compacting. Material particles are the result of deformation and strain exerted by external forces, mainly in contact areas. From the compacting point of view it is very important that the binding forces increase according to particle size. When the particle size is bigger, then the input power needed for compacting also has to be bigger, with the briquette having lower homogeneity and hardness. When the particle size decreases, the

binding forces decrease, which results in the briquette falling to pieces quickly during the burning process (briquette burns faster, which represents its disadvantage). Briquette quality decreases and the required compacting pressure increases with an increase in the material particle size. During pressing, but mainly during pressing without binding, the material surface planes have to touch over the largest possible area. The size of the contact plane of grains increases with the increase of material smoothness and compacting pressure.

Fig. 4 Three-dimensional cross-section of softwood – pine (left), pine sawdust (in the middle) prepared for pressing and pressed briquette from pine sawdust (right) [3]; [6].

Fig. 5 Three-dimensional cross-section of hardwood – beech (left), beech sawdust (in the middle) prepared for pressing and pressed briquette from beech sawdust (right) [3]; [6].

If we respect these material properties and patterns we are able to produce quality briquettes from each type of wood or material. Therefore is very important to know which technological parameters need to be provided during the compacting process for producing briquettes with standard given quality. Every type of material has different mechanical and thermal properties and different chemical composition. Therefore is needed to do experiment step by step for all types of materials. All described material properties influence the quality of the compacting process and briquette quality which is evaluated mainly by density. During the pressing process there are many parameters which influencing the final briquettes quality – density. On our department we made some analyses and experiments to detect the impact of these parameters. It is very important to produce briquettes conforming to given quality standards. The briquette density value provided by the EU Standards is 1,14 $kg.dm^{-3}$ [4]. The experiment was evaluated using this value of briquettes density.

EXPERIMENT – DESIGN, EVALUATION, RESULTS

The experiment was done on our experimental pressing stand. On this stand we are able to change the pressing temperature and compacting pressure – which was needed. Pressing temperature was changed from 85 ºC to 115 ºC. The compacting pressure was changed from 61 MPa to 191 MPa. We tested four types of materials – two from the group of softwoods (pine and spruce) and two

from the group of hardwoods (beech and oak). During this experiment we used only one particle size (2 mm) and one value of material moisture content(10%) from each of the tested materials.
In the experiment we focused on detecting the differences between various materials behavior throughout the compacting process according to the final briquette density. On the following dependencies you can see the reached results.

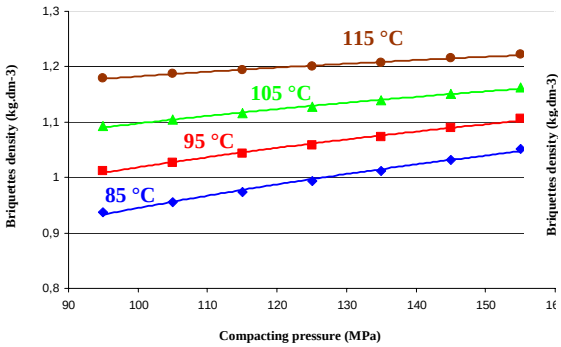

Fig. 6 Dependence of briquettes density on compacting pressure by various pressing temperatures for pine sawdust (w_r=10%; L=2mm) [1].

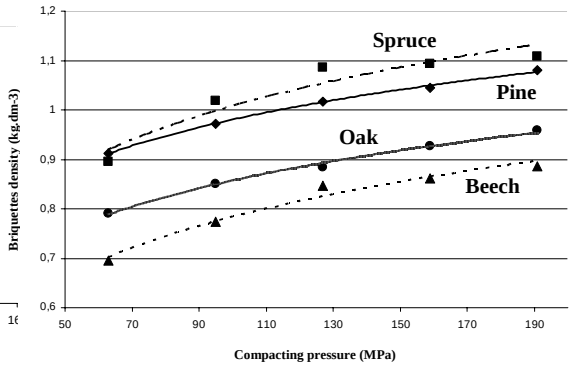

Fig. 7 Comparison of dependencies of briquettes density from various materials from compacting pressure by pressing temperature 115ºC (w_r=10%; L=2mm) [5]; [6] .

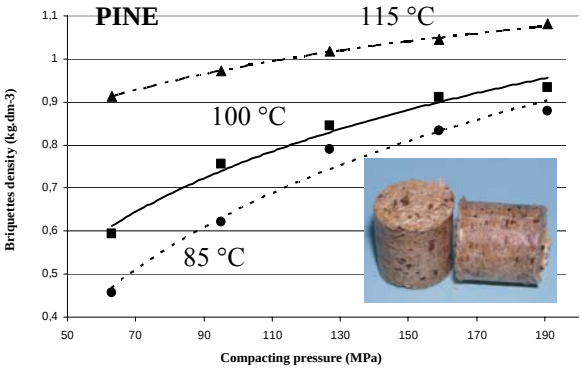

Fig. 8 Dependence of briquettes density from pine sawdust from compacting pressure by various pressing temperatures (w_r=10%; L=2mm) [5].

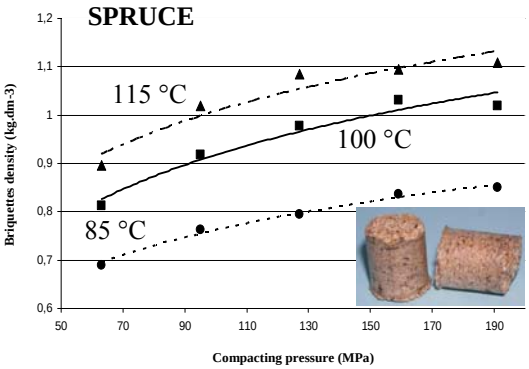

Fig. 9 Dependence of briquettes density from spruce sawdust from compacting pressure by various pressing temperatures (w_r=10%; L=2mm) [5].

From previous and subsequent results it is clear how important the type of material is during the compacting process – both briquetting and also pelleting. Among the other significant quantifiable parameter that are also important, the pressing temperature and material moisture have the greatest influence. It's true that pressing temperature is not a direct parameter of the pressed material but significantly influences some material properties, changing and influencing also the material structure and chemical composition during the compacting process. Briquettes from materials with

higher lignin and cellulose contents – softwoods (pine, spruce) have evidently higher density than briquettes from hardwoods (oak, beech).

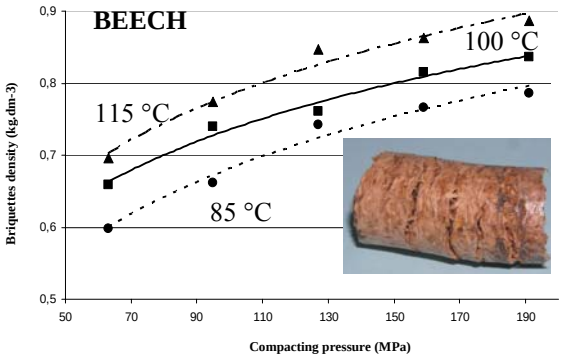

Fig. 10 Dependence of briquettes density from beech sawdust from compacting pressure by various pressing temperatures (w_r=10%; L=2mm) [5].

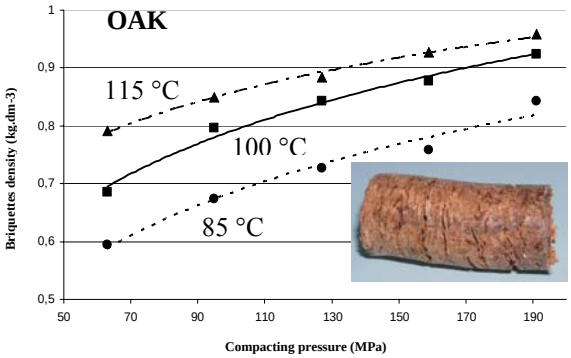

Fig. 11 Dependence of briquettes density from oak sawdust from compacting pressure by various various pressing temperatures (w_r=10%; L=2mm) [5].

CONCLUSION

On the base of presented executed analyses and results obtained from the experiment we clearly proved the importance of the pressed material type during the compacting process. The parameters which influence and enter the compacting process come not only from the pressing process itself but also from the foregoing processes - processing of the material treatment and its preparation - disintegration, separation and drying. Therefore it is very important to know the optimal parameter values which influence final briquette quality for various types of materials.

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